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STANFORD UNIVERSITY SCHOOL OF MEDICINE  
Department of Genetics

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Dr. Croften Barney Farmer  
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Dear Barney,

Thank you for sending the figures.

In the light of the equilibrium to which the cryobiological discussion may be tending I think it would be most valuable if you would use another object parameter in your calculations: namely the occurrence of ice at a maximum temperature of 260K. If I read your figure 9 correctly this would allow for a sublimation rate of  $5\mu/\text{min}$  at 10mb atmospheric pressure which seem like plausible values to take. On a full frosting model, say  $30\mu$  every morning, this could give our bugs all of 6 minutes during the warming cycle during which they could acquire their necessary moisture; then, of course, we have to postulate that they are adapted to much lower water activities for their continued internal metabolism at still higher temperatures. Mixing the frost in with soil should allow still further improvements on these parameters whether or not one succeeds in making a persuasive case for reaching the liquid state for any period of time. We still end up with the idea that either the Martian bugs have an extremely short period during which they can actively grow during a diurnal cycle or else that they have an adaptation to aridity that goes far beyond anything to which any earthly organism has adapted. These are both discouraging prospects, and ones to which the actual Viking biology experiments have not really addressed themselves; nevertheless, they really do not foreclose the possibility of a vigorous biosystem.

On the other hand, if we can get sufficiently far north to reach the southernmost extension of the annual cap there then should be a fairly substantial winter deposit that persists for some time before it sublimates away -- which is, of course, exactly what we observe every summer. The question remains how much of this is under a regime that exceeds the 260 limit, which is a point possibly only slightly more comfortable than the previously asserted 273, but perhaps just enough that we might have a reasonable persuasiveness in propounding it.

On this model Martian life might be confined to a fairly narrow subpolar zone which, of course, remains as the rationale for the proposed B mission. These organisms will, of course, have internal "liquid water" kept from freezing by solutes and perhaps even by the evolved reliance upon solutes which are particularly efficient in injuring crystallization. When water is maintained in compartments individually as small as  $1\mu$  dimension

over

FARMER, C.B.

it can, as you know, be supercooled quite extensively without running much risk of crystallization. But for this discussion I do rely mainly on the reported observation of microbial growth down very close to 260 as remarked in Wolf's letter.

If there are organisms at the top of the water chain that can extract moisture at 260 there will surely be predators which will use these as the primary source of their own moisture and can function presumably at much higher temperatures. This phenomenon would be more characteristic of the intermittent distribution of ice as might be expected in the tropical zone with shaded areas. So, there is obviously every reason to try to validate this model which could be done by the mere observation of frost reaching the ground even in terrain of low relief, such as we presumably seek for the landing of the A mission.

It is still extremely important to look for the possible variances around the "average extreme temperatures" calculated by Kieffer.

My summary recommendation would be to target mission B just as far north as we can credibly predict the occasional occurrence of reaching the 260 threshold for at least a few days a year. It would be better if our landing time coincided with this but not absolutely crucial as we should still be able to find the hibernating forms and the fall traces of the summer's growth.

Sincerely yours,

Joshua Lederberg  
Professor of Genetics

JL/rr